

## Project 3

### Measurement of Selenium Loads to Great Salt Lake

SUBCONTRACT WITH: University of Utah & United State Geological Survey (USGS)

PRINCIPAL INVESTIGATORS: Dr. David Naftz/USGS, Dr. William Johnson/University of Utah

CONTRACT VALUE: \$172,277

SCHEDULE: April 1, 2006 through September 30, 2008 (elapsed time: 33 months)

## Project Objective

The project objective generally is to measure and model selenium loadings from major input sources to the open water of Great Salt Lake (South Arm of GSL, excluding Farmington Bay). Please see Data Quality Objectives for Project 3 for further detail.

## Scope of Work

### Task 1. Preparation of workplan, budget estimates, and data quality objectives

**Justification:** Prior to executing Project 3, a workplan and the associated components need to be prepared and then reviewed by the Great Salt Lake (GSL) Science Panel, Utah Division of Environmental Quality, technical advisors, and GSL Steering Committee .

**Approach:** Participation in study team meetings, conference calls, and other tasks on an as-needed basis. Also include the development and subsequent revision of the Project 3 workplan, oral presentation material, and data quality objectives.

#### **Deliverables:**

1. Oral presentation material for steering committee meeting (completed in March).
2. Draft and Final Data Quality Objectives for Project 3 (completed by 4/28/2006).
3. Workplan including scope of work, projects costs, project schedule, health & safety plan, protocol for (1) establishing and maintaining gaging stations, (2) collecting, handling, and shipping samples (completed by 4/28/2006).

### Task 2. Install stream gages on all primary point sources of Selenium loading to the main body of GSL

**Justification:** With the exception of intermittent selenium loading data provided by the Kennecott Utah Copper Corporation (KUCC), selenium loading data to main body of GSL do not exist. Selenium loading data is a critical component to understanding current and future selenium cycling and subsequent biological responses in GSL. In cooperation with the Utah

Division of Wildlife Resources, the USGS has operated stream gages that measure inflow to the main body of GSL from Farmington Bay and the Bear and Weber Rivers.

Although the existing USGS gages likely monitor a large part of the surface water selenium load to GSL, additional gages are needed to compliment the existing gages. In order to fully quantify the selenium loadings to main body GSL, three additional sites require USGS stream gages: (1) Goggin Drain; (2) Lee Creek; and (3) KUCC outfall. Detailed selenium loading data is needed from these sites to support the biota sampling in Project 1 that will occur along the southern shores of GSL. Although the KUCC outfall is currently measured and sampled by KUCC personnel (for consistency and full data availability), this site should be operated and monitored by USGS personnel. Therefore, this project includes the installation, maintenance and operation of a new USGS gage at the KUCC outfall. To complete the selenium loading measurements to the south arm, the determination of selenium loads from the north arm are also required. It would not be cost effective to install permanent gages on the culverts and breach conveying water between the north and south arms; however, the USGS currently measures discharge at three points along the railroad causeway. In conjunction with this ongoing project (funded by the State of Utah and USGS), selenium samples will be collected for estimation of selenium loads entering from the north arm of GSL.

Finally, the completion of the south-arm stream gaging network will provide the infrastructure for future development of water-quality standards for other trace elements of concern.

**Approach:** The USGS will reactivate the Weber River gage in early April. Installation of stream gages at the KUCC outfall, Goggin Drain, and Lee Creek will begin in early April, according to methods outlined in (Carter and Davidian, 1989). Measurement of stream discharge (15-minute intervals) by the USGS will begin as soon as possible at all sites, with frequent site visits by USGS personnel (usually in 6-week intervals) for development of rating curves. A data collection platform (and associated equipment) will be installed by the USGS on each gage, allowing the satellite uploading and subsequent display of real-time discharge data for each gage (via the internet). The display of real-time discharge data will result limited loss of discharge data because the hydrologic technician will be able to monitor equipment performance on a daily basis, instead of relying on site visits that only occur every 6 weeks.

The USGS will use equal discharge or equal width increment techniques to collect composite selenium samples at monthly intervals at each site. Whole-water and dissolved selenium samples will be collected and processed by the USGS using USGS part-per-billion protocols (USGS, 2003). Water samples will be analyzed under a separate contract using hydride generation atomic fluorescence spectrometry at the laboratory selected and approved by the Utah Division of Water Quality (UDWQ)/Great Salt Lake science panel. Approximately 10 percent of the samples will be process blanks, equipment blanks, and replicates for quality assurance/quality control (QA/QC) requirements.

On a less frequent basis (6 to 8 week intervals), whole and filtered water samples will be collected by the USGS and analyzed for selenium at three points along the railroad causeway in conjunction with discharge measurements supported by an ongoing USGS project. In addition, the surface-water outflow from the Morton Salt evaporation ponds (in the southwestern corner of GSL) will be measured. Water samples will also be collected by the USGS for selenium analysis (whole water and filtered) four times per year. Figure 1 displays all proposed surface-water inflow monitoring locations.

In order to capture the variable selenium loads during the spring runoff, autosamplers will be installed and operated by the USGS at three sites (Goggin Drain, Farmington Bay outflow, and Bear River). The autosamplers will be deployed from mid-April to mid-June 2006 and 2007. While daily samples will be collected by the USGS during this time period, only a few will be selected for whole water selenium analysis, based on the stream hydrograph (gaining and falling limbs). To accurately monitor the selenium loads during “flushing” of evaporation ponds operated by Great Salt Lake Minerals, an autosampler will be deployed by the USGS at the Bear River gage during November 2006 and November 2007. A daily sample will be collected by the USGS with a few of those selected and submitted for whole water selenium analysis. Sample selection will be based on the Bear River hydrograph and the timing of evaporation pond flushing.

During the time period of autosampler deployment, at least two whole water selenium samples will be compared by the USGS to an Equal Width Increment or Equal Discharge Increment sample collected across the entire stream cross section. The comparison will be used to document how representative the near-shore point sample collected from the autosampler will be to the actual whole water selenium concentration for the entire stream cross section.

During the two years of gage operation, four samples from each gage site (a total of 8) will be analyzed for selenium species (selenate, selenite, and organic selenium). Results from the selenium speciation will be used as a forensic tool to discriminate between the major selenium inflow sources to GSL. In addition, the selenium speciation results will be compared to the biological monitoring data collected in Projects 1 and 2 to discern any differences in selenium toxicity effects from the inflow sources.

**Assumptions:**

1. The estimated level of effort and number of samples is documented in the contract. No additional samples will be collected or analyzed for mercury.
2. Cost for gages includes furnishing all labor, materials, permits, tools, equipment, and incidentals necessary for installation, maintenance, operation, reporting and other appurtenant work for each gaging station for the defined period. Any easements or right-of-way for access to gage locations are also included.
3. It is assumed that KUCC will provide all daily water quality and discharge data they collect from their outfall in a timely manner for inclusion in this work. KUCC’s daily sample data will be compared against new USGS samples collected as part of this work.
4. It is assumed that gages for Farmington Bay and Bear River outfall are in place and actively maintained, operated and monitored as part of other USGS work. Operation and maintenance costs for these gages are not included in this scope of work. In the event that these programs are not funded in the future, UDWQ will have the opportunity to fund these gages before deactivation.
5. Intermittent discharge measurements along the railroad causeway (3 sites) are funded by ongoing USGS programs and are not included in this scope of work. In the event that this measurement project is not funded in the future, UDWQ will have the opportunity to fund this activity before it is discontinued.

6. In the event that UDWQ terminates the stream gage operation prior to the contracted period of 2 years, UDWQ will be charged for labor to remove the installations. This cost is not included in this scope of work. USGS will maintain ownership of all gaging equipment.
7. USGS cooperative funds designated for this project are subject to annual changes in the Congressional allocation to the U.S. Geological Survey. It is the intention of the USGS to allocate the agreed upon funds to Project 3; however, there is the potential that these funds will not be available in future Federal fiscal years. In the event of a funding decrease, the UDWQ will be notified and in cooperation with UDWQ, this scope of work will be revised to reflect the decrease in Federal funds.
8. All work will follow UDWQ's Quality Assurance Plan protocol. Samples will be shipped to the laboratory selected by UDWQ following required protocol. Cost of laboratory analysis is not included in this scope of work.
9. Laboratory data will be validated by CH2M HILL and imported to USGS database in a timely manner. If required, labor required by the USGS database manager for data transfer and associated activities will be billed to CH2M HILL, at the standard hourly rate of \$100/hour (see Utah Water Science Center data rates: <http://ut.water.usgs.gov/pricing.html>), after agreement upon scope of work and cost. This is not currently in this scope of work. Any data posted to the USGS National Water Information System (NWIS) database shall be considered public domain and owned by the public.

#### **Deliverables:**

1. Weber River gage will be reactivated. New USGS gages will be installed at Goggin Drain, KUCC outfall, and Lee Creek. Gages will be operated and data reported from March 2006 – February 2008.
2. Water quality samples, including QA/QC samples, delivered to laboratory selected by UDWQ per sampling protocol.
3. Progress updates in the form of data graphs and statistical summaries will be provided to UDWQ or designee upon demand. Data requests cannot exceed 2 requests per 12-month study period.
4. Data will be provided for inclusion in Year 1, Year 2, and Year 3 annual reports.
5. After USGS approval, discharge data from each gage site will be published in the USGS Annual Data Report for water years 2006 (partial record), 2007 (full record), and 2008 (partial record). After approval, the water quality data will be available to the public via the USGS NWIS web data platform.
6. Discharge data from the Weber River, KUCC outfall, Lee Creek, and Goggin Drain sites will be available to the general public in real time via the USGS real time streamflow web site. The data will be designated as provisional, until approval and released by the USGS.

### **Task 3. Modeling of daily selenium loadings to the GSL**

**Justification:** Daily variations in selenium loads from each gage site are needed to accurately estimate and compare selenium loads from all surface water sources to GSL. It is logistically

and financially impossible to collect daily selenium samples from each of the GSL gage sites described in Task 2. Instead, modeling techniques can be used to predict daily selenium loadings from each gage site to GSL. The modeled daily selenium loads will provide data for more precise determination of annual selenium loads to GSL, and allow for more accurate comparisons of loads from each loading source. In addition, modeling of daily selenium loads will allow for the comparison of daily, weekly, and seasonal changes in selenium loads in different areas during critical nesting times, as well as other seasonal biological cycles of concern by the GSL study team.

**Approach:** The daily mass loading of selenium from each gaging site will be estimated by the USGS using the newly developed USGS software, LOADEST (Runkel et al., 2004). Modeling parameters will include mean daily discharge, date, season, and measured selenium concentration/load. The automated model selection in LOADEST will be used to select the best regression model from the set of nine predefined models. Under the automated selection option, adjusted maximum likelihood estimation will be used to determine model coefficients and estimates of daily selenium load. The predefined model with the lowest value of the Akaike Information Criterion statistic will then be used for final selenium load estimation.

The initial loading models will be based on data collected from March through October 2006. Selenium loading models for each gage site will be updated on an annual basis, as more data become available.

#### **Deliverables:**

1. Preliminary model results, based upon data collected March through October 2006. These results will be summarized in the Year 1 annual report.
2. Preliminary model results, based upon data collected March 2006 through October 2007. These results will be summarized in the Year 2 annual report.
3. Final model results, based upon data collected March 2006 through February 2008. These results, along with methods, assumptions and observations, will be summarized in the final Year 3 report. The USGS/University of Utah will have the option to publish the results in the scientific literature. The UDWQ will maintain the right to review, critique and contribute to any manuscripts that are being prepared.

## **Project Deliverables**

1. Year 1 report on estimated annual selenium loadings from surface water. All annual reports will document activities, methods, assumptions, recommendations, and conclusions completed during that year (completed by 12/31/2006).
2. Year 2 progress and data report, on stream discharge and selenium loadings, to GSL and estimate of groundwater selenium load to GSL (completed by 12/31/2007).
3. Year 3 modeling of loading data and associated model report of mean daily selenium loadings from all surface water inflows to South Arm GSL, from March 2006 to February 2008 (completed by 9/30/2008).
4. Task deliverables are described in the following Project Schedule.

## Project Schedule

|  | CY 2006 |    |    |    | CY2007 |    |    |    | CY2008 |    |    |    |    |
|--|---------|----|----|----|--------|----|----|----|--------|----|----|----|----|
| Task Deliverable                       | Q1      | Q2 | Q3 | Q4 | Q1     | Q2 | Q3 | Q4 | Q1     | Q2 | Q3 | Q4 | Q1 |
| Install gages                          |         |    |    |    |        |    |    |    |        |    |    |    |    |
| Gage operation/sample collection       |         |    |    |    |        |    |    |    |        |    |    |    |    |
| Selenium analysis                      |         |    |    |    |        |    |    |    |        |    |    |    |    |
| Preliminary selenium loading estimates |         |    |    |    |        |    |    |    |        |    |    |    |    |
| Loading model development              |         |    |    |    |        |    |    |    |        |    |    |    |    |
| Modeled selenium loads/report          |         |    |    |    |        |    |    |    |        |    |    |    |    |

## References

Carter, R.W., and Davidian, J., 1989. U.S. Geological Survey, *Techniques for Water-Resources Investigations*, Book 3, Chapter A6, pg. 13.

Runkel, R.L., Crawford, C.G., and Cohn, T.A., 2004. *Load estimator (LOADEST): A FORTRAN program for estimating constituent loads in streams and rivers*: U.S. Geological Survey *Techniques and Methods*, Book 4, Chapter A5, pg. 69.

U.S. Geological Survey, 2003. *National field manual for the collection of water-quality data*: U.S. Geological Survey *Techniques of Water-Resources Investigations*, book 9, chaps. A1-A9, available online at <http://pubs.water.usgs.gov/twri9A>.

FIGURE 1

Locations of Surface-Water Monitoring Sites on the South Arm of Great Salt Lake

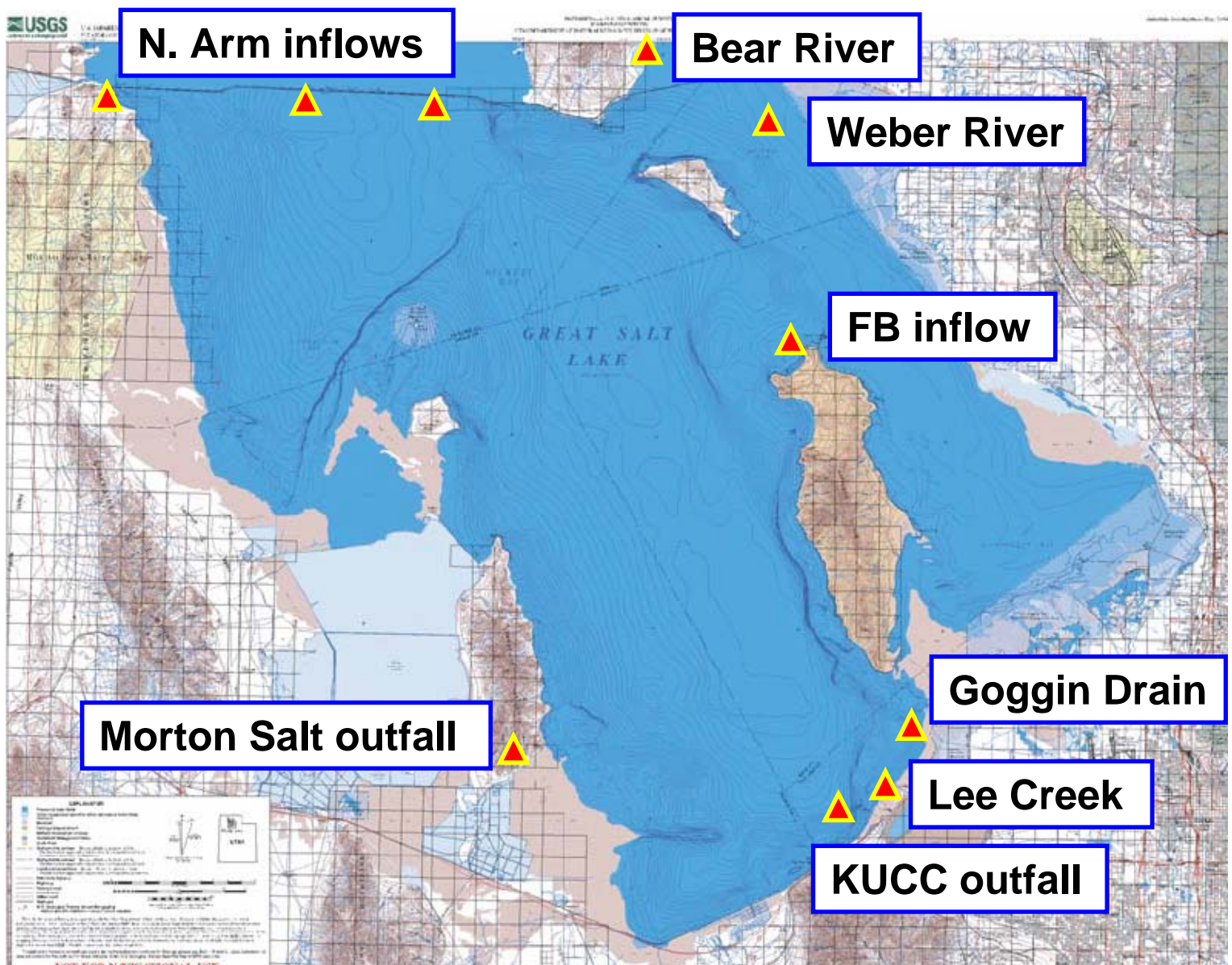


TABLE 1

Total Number of Samples of Total and/or Dissolved Selenium Sample Collection at Each Gage Site

| <b>Year 1 (3/06 to 2/07)</b>  | <b>Month</b> | <b>Total</b> |
|-------------------------------|--------------|--------------|
| Discharge & Sample Collection | March        | 12           |
| Discharge & Sample Collection | April        | 12           |
| Discharge & Sample Collection | May          | 52           |
| Discharge & Sample Collection | June         | 28           |
| Discharge & Sample Collection | July         | 12           |
| Discharge & Sample Collection | August       | 20           |
| Discharge & Sample Collection | September    | 12           |
| Discharge & Sample Collection | October      | 12           |
| Discharge & Sample Collection | November     | 26           |
| Discharge & Sample Collection | December     | 12           |
| Discharge & Sample Collection | January      | 12           |
| Discharge & Sample Collection | February     | 20           |
|                               | <b>TOTAL</b> | <b>230</b>   |

| <b>Year 2 (3/07 to 2/08)</b>  | <b>Month</b> | <b>Total</b> |
|-------------------------------|--------------|--------------|
| Discharge & Sample Collection | March        | 17           |
| Discharge & Sample Collection | April        | 12           |
| Discharge & Sample Collection | May          | 52           |
| Discharge & Sample Collection | June         | 28           |
| Discharge & Sample Collection | July         | 12           |
| Discharge & Sample Collection | August       | 20           |
| Discharge & Sample Collection | September    | 12           |
| Discharge & Sample Collection | October      | 12           |
| Discharge & Sample Collection | November     | 26           |
| Discharge & Sample Collection | December     | 12           |
| Discharge & Sample Collection | January      | 12           |
| Discharge & Sample Collection | February     | 20           |
|                               | <b>TOTAL</b> | <b>235</b>   |

Note: See Table 2 for additional QC samples and speciation samples.